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THE FULLNESS OF TIME[1]

PERSONAL EXPERIENCE FROM A HALF CENTURY IN ENGINEERING EDUCATION

By Dr. ARTHUR M. GREENE, JR.

DEAN, SCHOOL OF ENGINEERING, PRINCETON UNIVERSITY

THE eighth decade of the nineteenth century marked the beginning of the electric light and power industry, following the introduction of the incandescent lamp of Edison in 1878 and of the electric motor in 1873 at the Vienna Exposition.

The Jablochkoff candle had been used for street lighting from 1877 and many were employed throughout Europe. Its limitations prevented extensive use and other arc lamps were developed. This lamp, suitable for street lighting, was not adaptable for residences and offices.

The principle of the electric motor was known to Faraday in the early part of the century, and Siemens had suggested the use of the dynamo machine as a motor in 1867. However, it was not until a chance connection of a generator of Fontaine and Breguet to a power line from another of their machines at the Vienna Exposition that the fact that motors are generators operated from an electric supply was fully realized. From that time on the electric motor became an element of power transmission.

The field of electric light and power was extended into all parts of the world, and in this eighth decade the technical press was filled with notices of organizations of power companies and with invitations for bids to furnish equipment.

The power plants of 1888 were limited as much by the facilities of manufacture and erection and by the demands for service as by the engineering knowledge of that day. The Edison Electric Company of Philadelphia built its plant near the center of the district

[1] Address delivered at the annual spring meeting of the Rensselaer chapter of the Society of Sigma Xi, Troy, N. Y.

devoted to shopping, banking and the practice of law. The cost of copper was the controlling factor which located this plant on expensive ground, at a distance from transportation facilities and where no condensing water was available. The effectiveness and convenience of the electric light and the electric motor made such plants, expensive in construction and operation, commercially possible.

The necessity of high potential for utilization of energy at any distance from the power station was recognized and the alternating current system for this purpose was suggested by Gailard and Gibbs in 1883, using Ruhmkorff coils, the secondaries of which could be sectionalized to give any desired voltage. From this suggestion the transformer was developed and the final steps were the inventions and uses of polyphase currents by Ferraris and by Nikola Tesla in 1888 and the rotating field motor of Debrowalsky in 1891.

The street cars were drawn by horses and the automobile was not in evidence. Edison had worked on electric traction in the early eighties, but it was in 1888 that Frank Sprague installed the first real city system in Richmond, Virginia.

The gas engine of this period was not reliable in small sizes, and although Lenoir had used the jump spark for ignition in his successful engine of 1861, the gas engines of my college days used a hot tube for this purpose. The compression of the explosive mixture into a heated, closed tube fired the charge. The heat was applied near the end of the tube and timing of ignition was fixed by selecting the proper length tube from a supply of different lengths.

The hydraulic turbines of this time were small, three hundred horsepower being a large unit capacity. The theory of such machines had been studied by Weisbach, Bodmer, Francis and many others since the early Fourneyron turbines of 1827, but in this country at least most of the development was by trial and error, using the testing flume (1872) of Emerson at Holyoke, Mass., to determine the improvement produced by changes in design.

The use of the telephone had increased so that by 1890 there were several hundred thousand subscribers. In 1887 the pole line on West Street, New York, had twenty-five cross arms and the aerial lines on lower Broadway appeared as a collection of spider webs. The underground cable was being installed at this time although only fifty pairs of wire were used in one cable. Long distance telephony was a cherished hope, to be carried to Chicago in 1892.

Steel and iron were used extensively at this time with the Bessemer patent expiring in 1890. The great production of later decades had not been reached, and it was not until 1892 that the first trainload of Mesabi ore entered Duluth.

Petroleum had been found in the Appalachian field, in California and Indiana, and in 1889 the great midcontinent field was first drilled. Indeed, the output at this time was so limited that the possibility of fuel oil in any great quantities was denied by the chief chemist of the Pennsylvania Railroad, Dr. Dudley.

The office buildings of this date were of moderate height, tall buildings being those of ten and twelve stories. Steel frames were used, but reinforced concrete had not been introduced to any great extent.

Into this state of engineering I had my introduction to the profession at preparatory school age in the Central Manual Training School of Philadelphia. My father was attracted by this new type of high school which had just been introduced into America. Philadelphia was one of the early cities to adopt the new method and I was a member of its second class to graduate in 1889. The educational philosophy of the school was to train the hand while developing the mind and although the curriculum was in a formative stage, it was well planned. In addition to preparing some city boys for positions in manufacturing, a number of my classmates went on to college and have become teachers of philosophy, chemistry, English and engineering. In their chosen fields they have won distinction.

The curriculum of this school prepared men for college as well as industry, not by the means of electives or different schedules but by a single curriculum which was offered to all. There was need for such a new high school to fit the graduates for gainful employment in positions created by the developments which were taking place in engineering and in manufacture, if further formal education was not possible.

I entered the Towne Scientific School of the college department of the University of Pennsylvania in 1889. The courses of this school led to a B.S. degree in four years with some specialization after the sophomore year, to be followed by a graduate year for the technical degree.

At the end of the sophomore year the student had to elect a field of specialization from the following: chemistry, metallurgy and mining, civil engineering, dynamical engineering and architecture, and in the junior year the real engineering work began.

It was at the end of my sophomore year that the university inaugurated four-year courses in engineering to meet the demand for such throughout the country. Most of the engineering schools were offering these and the number of applicants for admission to Pennsylvania was small because of the attraction of the shorter curricula elsewhere. The university offered at first three undergraduate courses leading to the degrees of B.S. in C.E., B.S. in M.E. and B.S. in E.E.

The chemical engineering course was established in 1895.

On the completion of my undergraduate course, definite changes were taking place in the engineering world, as indicated by the direct-connected engine generator units of the World Columbian Exposition, Chicago, 1893, the electrical illumination and the intermural electric railroad of the exposition, by the three short transmission lines in France at Gyannax, Domène and Paris of 1890, and by the Frankfort-Lauffen line of one hundred and six miles, the Rome-Tivoli line of eighteen miles, the three-mile line at Telluride, Colorado, and the twelve-mile line from Willamette to Portland, Oregon, of 1891.

Two operating steam turbines were exhibited at the Chicago Exposition—one a 300 K W de Laval unit, and the other a 50 K W unit of Parsons. A still unit of 500 K W was exhibited by Parsons, who had built units up to 150 K W for the Newcastle and District Lighting System of Great Britain.

My summer job in 1893, before returning for the graduate year, was on the power house of the Peoples Traction Company, which was installing the first of their street railway electrifications of part of the city of Philadelphia. This year, 1893, marks also the first hydraulic turbines installed in power house No. 1 at Niagara Falls.

Following my graduate work I taught at the Drexel Institute for a year and then returned to the university as an instructor in mechanical engineering, teaching from year to year the courses of the mechanical engineering schedule.

Before going to the University of Missouri in 1902, I aided in planning the mechanical engineering laboratory for the University of Pennsylvania, which was erected in 1905, but on entering upon my new position in the Middle West a mechanical laboratory had to be equipped and a course had to be planned to meet the needs of that period, as the previous curriculum had been largely based on the mechanic arts rather than upon engineering.

Three courses were offered at Missouri in 1902: civil, mechanical and electrical, and these were altered from year to year to meet the engineering requirements of the period 1902 to 1907 and to fit the preparation of students coming from the approved high schools of the state of Missouri.

In 1907 the requirements for admission to engineering were fifteen Carnegie units, of which three were required in English, three in mathematics, one in science and two in a foreign language. The students from accredited high schools were admitted without examination on the presentation of proper credentials.

It was while administering the courses at Missouri, as junior dean of the school, that I received a telegram in the spring of 1907 from P. Cricketts asking me if I could see him at the university on a certain day but with no further information. I did not know P. Cricketts, but on asking one of my associates if he knew such a person, he at once said that it must be P. C. Ricketts, who had received a million dollars from Mrs. Russell Sage with which to inaugurate a course in mechanical engineering at the Rensselaer Polytechnic Institute. He suggested that President Ricketts probably desired to talk with me about mechanical engineering. He came to Columbia and we had a frank discussion regarding engineering education, including the value of Rankine's books and allied subjects, and he left us on the late night train for the north.

After some weeks I was asked to meet a number of the faculty and trustees at a dinner at the home of Director Ricketts and I visited the buildings of the institute, which at that time consisted of the Carnegie Building, the Walker Laboratory, the Proudfit Building, the Rankine House, the Warren House, the old chemical laboratory on Eighth Street, the old gymnasium at the head of Broadway and the library, museum and administration offices in the Alumni Building on Second Street. This visit resulted in my call to Rensselaer that spring.

The planning of the curricula for the two new courses in mechanical and electrical engineering was carried out in such a way that they would be comparable with the civil curriculum with its two studies in the morning and the scholastic amusements of Amos Eaton in the afternoon. From past experiences in engineering education, it was not difficult to arrange our work, as we had the civil schedule as a guide. This schedule was the result of many years of development by which the general requirements for a Rensselaer degree were fixed. The important part of our work was to arrange the freshman year of the new courses to care for the men entering in September, and then to begin the planning of the Sage Laboratory which would be needed in two years for the junior students of the new departments.

The matter of shop work was discussed very carefully. From my experience it was decided that the vast amount of repeated work with hand tools should be eliminated as the object was not to make skilled artisans. All exercises were planned to illustrate various shop methods and, as far as possible by their comparison, indicate the reason for certain shop procedure. These exercises were selected to indicate also the behavior of tools and of different engineering materials on which shop manipulation was required by actually handling them. Another purpose of the shop course was to bring the students into actual contact with these tools and materials of modern construction so that they would understand the requirements of

manufacturing to be applied in engineering designs of the future. Shop work naturally fitted into four-week summer periods of two years, paralleling the two summer periods of surveying of the civil curriculum. It was also thought that by operating the shop on forty-four hours per week the tasks of the industrial worker might be realized in part by the students.

In the planning of these two new courses the only changes of the civil schedule of Division D (first year) were the elimination of topographical drawing and the shortening of the time for surveying, using these periods for elementary steam engineering.

As you may probably recall, all courses included French throughout Division D and the course in the English language during the first term Division C. A summer thesis was required at the end of each summer vacation.

The schedules for Division C (second year) followed the civil engineering patterns and included electricity, electrical laboratory and electrical measurements in place of surveying and surveying practice of the first term with machine drawing, kinematics, physical laboratory and electrical laboratory for perspective, shades and shadows, surveying and free-hand drawing of the civil course of the second term.

The studies of Division B (third year) of the two new courses were quite different from the civil curriculum as the only courses in common were rational mechanics, resistance of materials, structures and metallurgy.

The only common subjects of the three courses of Division A (senior year) were hydraulics of the first term and the graduating thesis. The remaining subjects were chosen for each curriculum to meet the requirements of that branch of engineering. The first E.E. and M.E. degrees were conferred at Rensselaer in June, 1911.

After fourteen years at Troy I was called to the deanship of a new school of engineering at Princeton University, which was inaugurated in 1921. During my fifteenth year at Troy I spent certain days at Princeton planning new schedules for the undergraduate course in civil engineering, which had been established in 1875, and for that in electrical engineering, which had been established as a graduate course in 1889, together with schedules in mechanical, chemical and geological engineering. Each of these four-year undergraduate courses led to the degree of B.S. in E.

This step had been taken by Princeton at the solicitation of the members of the Princeton Engineering Association and had been authorized by the trustees of the university on condition that the academic facilities of the university be used to the fullest extent.

Again, it was a problem of fitting courses into curricula of an institution with traditions and with established courses in arts and science and to use the civil course as a guide in placing as many applied technical subjects as possible into a fifth year of graduate work while retaining the fundamental engineering subjects. The retained courses were such that the student who could not return for the graduate year was prepared to continue study and development in the early days of his professional career.

The results of this study, as announced in the catalogue of 1922, provided for a common freshman year with English, a foreign language, analytic geometry and calculus, chemistry, engineering drawing and an orientation course, industrial development.

The sophomore year was practically common with electives in each term and a one-course difference in the second term between steam engineering and chemistry. The upperclass schedules contained few common courses, but there was a marked difference in the other required subjects. There was one academic elective each term.

The four graduate courses (civil, electrical, mechanical and chemical) were made up of applied engineering subjects, engineering economics, specifications and contract law being required in each.

All the schedules have received changes during sixteen years. These were made to equalize the work of each year and to meet changing conditions. At present the undergraduate studies are so divided that of the 144 credit hours of work required in the civil, electrical or mechanical courses, practically 30 per cent. may be treated as non-scientific or elective, 30 per cent. scientific and 40 per cent. engineering. The special departmental work of any one of these courses varies from 17 per cent. in electrical engineering to 23 per cent. in the mechanical course.

In the chemical engineering course 22 per cent. is non-scientific or elective, 46 per cent. scientific and 32 per cent. engineering, of which only one half is in chemical engineering.

In the geological engineering course, 30 per cent. of the 141 credit hours may be considered as non-scientific or elective, 49 per cent. scientific and 21 per cent. engineering.

Electives at Princeton extend through the complete list of academic departments, from art to psychology, and the elections vary from year to year.

After the arrangement of the courses of study for Princeton, the next problem was again to plan laboratory equipment, to enlarge the old and to create the new. As in my previous positions, I was fortunate in being associated with men of vision and understanding, and the laboratories have been fitted, regardless of those at other institutions, to suit the requirements of

our courses as we understand them. It was once more my pleasure to move into a new building which represents the hopes and aspirations of a cooperative staff.

I have drawn a partial picture of the state of engineering as it existed when I was completing my manual training school preparation for engineering education and now, a half century after this, I ask you to hastily recall the things which you have enjoyed during the last twenty-four hours which were not dreamed of as possibilities in 1888.

We have seen the extension of the use of the automobile and of superheated, high-pressure steam; we have enjoyed the facilities of long-distance telephony, the radio and household refrigeration. The two thousand horse-power engine of the Columbian Exposition has been replaced by the one hundred and thirty thousand horsepower hydro-electric generators and the two hundred and sixty thousand horsepower steam turbo-electric units. Transmission systems have extended for hundreds of miles and electric networks have reached over several states. Electrical load dispatching has become as common a term as train dispatching. The small vacuum tubes used by Dr. Robb and Professor Williams in a limited way before installing the Rensselaer broadcasting station have been further developed and are now made for all sorts of services, for repeaters, for wireless and for power.

It is the development of these things, occurring at intervals during this half century, which has caused us to change some of our courses, but basically they start from those subjects in which I was trained at the beginning of the period and those subjects are still the alphabet from which we have formed and will continue to form at least the first parts of our new words.

I have used "the fullness of time" in my title because I believe that such things have come from the work of previous generations. The dreamer can think of a great prime mover, but how can he build it without the travelling crane and the massive machine tools at hand or to be built by the facilities available at the time of construction. The same may be said of the transportation of these parts and the possible facilities at the erecting site. Boulder Dam and the gigantic numerical coefficients before each common term describing it represents research and application of results but without the handling facilities for these enormous quantities and unit pieces it would be merely a dream of a Jules Verne.

I think of the gas engines on which my students worked at Pennsylvania and even at Troy and the troubles experienced by them in attempted operation. Then came the demands of transportation which made these engines reliable devices for the unskilled and even ignorant driver. With this development their use spread to the air, entrance into which had been denied to the planes of Leonardo and of Langley because of the lack of power.

We could enumerate devices common to-day which have become possible by developments in some other field and so in enjoying any one device we should try to recall the other developments which have made this one possible and the developers who have risked their futures on the outcome.

Our age, because of the numerous conveniences for all people, is more interdependent than any preceding civilization, and that fact should be kept in mind at the present time. The present-day leisure and the present-day facilities for enjoyment have come from an economic civilization in which freedom of action and personal gain have been driving forces. These have produced a plentiful supply of useful devices for the benefit of all. It is true that some few organizers have made stupendous fortunes which have been spent wisely for the benefit of the people or unwisely in unrighteous living, but by this system leisure and its possible utilization for the larger enjoyment of life have come to the average man, termed by some the forgotten man. Time and space for many have been contracted by communication and transportation. Our country has been reduced to the size of one of its smaller states when business requires the transmission of a letter or the visit of an executive. The comforts of our homes, our offices, our places of recreation have increased during this period. These have been brought about by the free enterprise of those who saw at the end a possible return and were willing to maintain laboratories and staffs of experts to produce devices to lighten burdens and increase enjoyment. The selfish motive, if one wishes to call it that, did bring about these beneficial results for the masses. Without it a dull picture of indifference and inefficiency appears to my mind's eye. History should be studied by those who would change the order of life.

The great increase in the number of institutions for engineering education which occurred in the seventh and eighth decades of the last century was in response to the needs of that time which came from the expansion in manufacturing and transportation following the Civil War. The continued increase in the enrolment of our engineering schools has been brought about by the demands for technically trained men to carry on in the expanding field of manufacture, communications and transportation, and it is the job for the younger men here to-night to change our applied courses of instruction to the needs of the future, remembering that the first steps of the ladder will remain the same as before until they can be shifted efficiently to the preparatory schools.

OBITUARY

BEVERLY THOMAS GALLOWAY

Born October 16, 1863—Died June 13, 1938

FOR practically half a century the name of B. T. Galloway (as he always signed it) has been identified with the development of botany and agriculture, most of that time with the U. S. Department of Agriculture.

He was born at Millersburg, Missouri, on October 16, 1863. After the usual school preparation he enrolled in the University of Missouri. He graduated from the university in 1884 having specialized in botany and horticulture. He remained as assistant horticulturist until July, 1887, when he was appointed by Commissioner Coleman to the Section of Mycology in the U. S. Department of Agriculture.

The next spring, 1888, F. Lamson-Scribner, head of the section, resigned to become director of the new Agricultural Experiment Station of the University of Tennessee, and Galloway was appointed head.

The work on the nature, cause and control of plant diseases was developed rapidly. David Fairchild, Erwin Smith, Effie Southworth, Nellie Fealy, Newton B. Pierce, M. B. Waite, Walter Swingle, H. J. Webber, Theodore Holm, P. H. Dorsett, assisted in the work. The writer came into the group in February, 1893. It was a delightful association and a happy family of workers. Salaries were small and funds were scarce, but enthusiasm was high.

Galloway appreciated the value and necessity of fundamental research, but he never forgot that it must have practical application in view, if it was to appeal to Congress as representing the farmers and horticulturists of the nation. The development of fungicides and spraying equipment and methods and the effective control of black rot of the grape, apple scab and numerous other diseases demonstrated beyond question the practical value of the work. The section soon became the Division of Plant Physiology and Pathology, with an annual appropriation of about $20,000.

In September, 1900, Mr. William Saunders, chief of the Division of Gardens and Grounds, passed away. This was the oldest unit of the department. Secretary Wilson appointed Dr. Galloway chief of the Division of Gardens and Grounds, and the writer became chief of the Division of Physiology and Pathology.

It was the desire of Secretary Wilson that the Division of Gardens and Grounds, with its greenhouses and ground facilities, be associated more closely with the other plant work of the Department. Up to this time the plant work had been operated as five distinct sections which later became divisions. These were Gardens and Grounds, Botany, Plant Physiology and Pathology, Pomology and Agrostology, with total appropriations of about $20,000 each. Dr. Galloway and I had many times discussed the desirability of a closer union of the plant work. We determined to bring this about through the close cooperation of Gardens and Grounds and Plant Physiology and Pathology. We found a similar feeling among the other chiefs of divisions.

The proposition was presented to Secretary Wilson and received his approval. The Secretary's report for 1900 contains a chapter giving his reasons and approval of the plan. It was later approved by Congress and the general bureau organization adopted.

This was the beginning of a rapid expansion of the work of the Department. In 1903 Congress authorized the construction of a new building for the Department in accord with the general plans of the Park Commission. Dr. Galloway was appointed by the Secretary as chairman of a department committee to direct the preparation of plans and supervise the construction of the new building. He saw clearly the needs of the Department and insisted, with the support of the Secretary, in planning a building that could meet the expanding needs and that would be adapted for the work rather than being simply a beautiful monumental structure. He drew the sketch of what now constitutes the North and South department buildings. This was not obtained without a fight, but he was not averse to a fight when necessary. During the first year of Secretary Houston's administration Dr. Galloway was Assistant Secretary of Agriculture. He was able to accomplish many improvements in administrative procedure, personnel management and increased salaries and appropriations for research.

In 1913–14, he was selected as a dean of the New York State College of Agriculture, Cornell University. He returned to the Department in 1915 to give special attention to pathological problems in connection with seed and plant introduction.

Dr. Galloway has written on a wide range of subjects connected with botany and agriculture. He retired from government service in 1933, but continued his interests in the work until the day of his death.

He was actively engaged in a study of plants connected with hay fever and in organizing research in this field which will bear fruit in years to come.

He received the degree of LL.D. from the University of Missouri in 1902 and Dr. Agr. from the University of Maryland in 1923. He was a fellow of the American Association for the Advancement of Science.

As a friend and co-worker he was always kind and helpful, a delightful companion and an energetic leader, always quiet and unassuming.

He will be sadly missed by a host of friends.

A. F. WOODS

BUREAU OF PLANT INDUSTRY,
U. S. DEPARTMENT OF AGRICULTURE

SCIENTIFIC EVENTS

THE SCIENCE MUSEUM, SOUTH KENSINGTON

THE development of the Science Museum, South Kensington, is discussed in the report for 1937 of the advisory council, of which Sir Henry Lyons is chairman. As reported in the London *Times* the council states that the project now under consideration for the readjustment and expansion of the Government and collegiate institutions in the area between Kensington Gore and Cromwell Road has made it imperative to survey afresh the future function and progress of the museum.

The total exhibition space which is estimated to be necessary now amounts, owing to the rapid growth of science in the past 25 years, to 50 per cent. more than that envisaged by Sir Hugh Bell's Committee in 1912. According to this calculation the site area necessary, allowing for exhibition galleries on not more than three floors, is 310,000 square feet, and this would take up nearly all the space enclosed by the Natural History Museum boundary, Exhibition and Imperial Institute Roads and Queen's Gate. Even apart from this the rebuilding of the museum is in arrears of what was suggested in 1912, and the council emphasizes the urgency of the reconstruction of the center block, now eight years overdue.

There is a lack of accommodation which is apparent in many sections of the report. For example, all the library's space for bookstores will be exhausted by the end of this year, and it has already become necessary to find storage outside the museum for exhibits for which there is no room at present in the galleries.

The number of visitors during 1937 was 1,271,599, against 1,281,338 in 1936 and 1,327,190 in the peak year 1935. The new exhibits acquired numbered 1,202 —of which one was the Bryant and May collection of fire-making appliances, consisting of more than 1,300 items, now on loan to the museum. Library readers increased from 22,366 to 24,627 in the year, and some 12,000 volumes were added by gift, exchange or purchase.

Consideration is given in the report to each of the five divisions into which the collections are classified. One point made is that, owing to the rapid mechanization of farming, it has become desirable to acquire a selection of recently superseded farm implements, and several valuable acquisitions of the kind were made during a tour in Devon and Cornwall.

THE JANE COFFIN CHILDS MEMORIAL FUND FOR MEDICAL RESEARCH

AT the close of its regular quarterly meeting, held at New Haven, Conn., on June 14, the Board of Managers of The Jane Coffin Childs Memorial Fund for Medical Research reviewed the activities of its Board of Scientific Advisers and announced its program for the support of cancer research for the next three years. According to the statement, the primary purpose of the fund at present is to support research into the causes, and origins are to receive chief attention. Therapeutic investigations have been considered from the point of view of their contribution to knowledge of causes and origins.

Since the establishment of the Childs Fund at Yale University in June, 1937, the director and members of the Board of Scientific Advisers have given careful consideration to the program of the fund and have sought advice from directors of medical and cancer research, officers of foundations which support research and from investigators. The consensus of opinion of numerous consultants and of the Board of Scientific Advisers is that the most advantageous program is a combination of distributed grants-in-aid with a concentration of resources in the support of cancer research at a university medical school closely affiliated with a general hospital, including an active tumor clinic, where personnel and facilities are available for attack upon fundamental and clinical problems. In view of the developments in cancer research at Yale University and the desire of the Boards of the Childs Fund to build up that center of investigation, and because of the opportunities for cooperative research at the Yale University School of Medicine and in other departments of the university, it was decided to concentrate the major portion of the income of the fund on the support of cancer research at Yale University for the next three years. In addition, grants-in-aid have been and will be made for cancer research in other institutions in this country and abroad, in accordance with the terms of the deed of gift. When the Childs Fund was established last June the amount of the principal was appraised at $3,343,556.

The members of the Board of Scientific Advisers of the Childs Fund are:

Dr. S. Bayne-Jones, professor of bacteriology and dean, Yale University School of Medicine, *director*.

Dr. Rudolph J. Anderson, professor of chemistry, Yale University.

Dr. Ross G. Harrison, Sterling professor of biology, Yale University.

Dr. Peyton Rous, member, Rockefeller Institute for Medical Research.

Dr. M. C. Winternitz, professor of pathology, Yale University School of Medicine.

At its meeting the Board of Managers voted to recommend to the corporation of Yale University that Dr. George M. Smith, research associate in anatomy with rank of professor in the Yale University School

of Medicine, be appointed also a member of the Board of Scientific Advisers.

The Board of Managers is composed of the following members:

Honorable Frederic C. Walcott, Norfolk, Conn., *chairman.*
Albert H. Barclay, New Haven, Conn., *vice-chairman.*
Christie P. Hamilton, New York City, *treasurer.*
S. Winston Childs, Jr., New York City, *secretary.*
Starling W. Childs, Norfolk, Conn.
Edward C. Childs, Reading, Pa.
Richard S. Childs, New York City.
George Parmly Day, New Haven, Conn.
Dr. Charles Seymour, president of Yale University, *ex officio.*

Applications for aid from the fund should be addressed to Dr. S. Bayne-Jones, director, Board of Scientific Advisers, 333 Cedar Street, New Haven, Conn.

GRANTS OF THE GEOLOGICAL SOCIETY OF AMERICA

NINETEEN research projects will be carried out in the United States, Mexico and Canada this summer under grants from the Geological Society of America. The list of grants, aggregating $17,073, follows:

Dr. Louis B. Slichter, professor of geophysics, Massachusetts Institute of Technology, $5,350 for a large-scale seismic investigation of the earth's crust in New England.

Dr. Perry Byerly, professor of seismology, the University of California, $900 for an investigation to determine whether various portions of the earth's crust have free vibration periods during earthquakes.

Dr. David Griggs, research physicist, Harvard University, $675 for constructing instruments to test the deformation of rocks under high confining pressures in the laboratory.

Dr. Harry J. Klepser, instructor in geology, Capital University, Columbus, Ohio, $300 to complete a detailed stratigraphic study of rock formations of Lower Mississippian Age in the Highland Rim of central Tennessee.

Dr. Harold R. Wanless, associate professor of geology, the University of Illinois, $1,542 for field studies of rock formation of Pennsylvanian Age in Kentucky, Tennessee, Alabama and possibly Virginia.

Dr. Claude C. Albritton, instructor in geology, Southern Methodist University, and Dr. Kirk Bryan, professor of geology, Harvard University, $500 for an investigation of Ice Age deposits near Alpine, Texas, containing human remains and fossils of extinct animals.

Dr. Ernst Cloos, associate professor of geology, the Johns Hopkins University, $990 for a study of the age of the Glenarm rock series in Pennsylvania and Maryland, which has long been in dispute.

Charles S. Denny, instructor in geology, Harvard University, $355 for a study of the Santa Fe formation of Tertiary Age, in the region north of Santa Fe, New Mexico.

Max Demorest, fellow in the Graduate School of Princeton University, $400 for the detailed study of an area extending across the Bighorn Mountains of Wyoming from Bighorn in the east to Shell Creek Canyon on the west.

Fred B. Phleger, Jr., instructor in geology, Amherst College, $500 for a study of microscopic animal life in submarine cores, recently taken from the North Atlantic Ocean.

Dr. Kenneth E. Caster, curator of the Museum of Paleontology of the University of Cincinnati, $500 to restudy and illustrate North American pelecypods, or clam-like fauna, of the Devonian Period.

Dr. Edward B. Mathews, professor of geology, the Johns Hopkins University, $700 to continue his work in collecting analyses of all igneous rock from North America and elsewhere.

Dr. R. W. Imlay, research associate, Museum of Paleontology of the University of Michigan, $835 for field studies of stratigraphy and paleontology and studies of connections between the Atlantic and Pacific across northern Sonora, Mexico, that existed during the Mesozoic Era.

Dr. Gilbert D. Harris, professor of paleontology, Cornell University, and Dr. Katherine Van Winkle Palmer, of the Paleontological Research Institution, Ithaca, N. Y., $700 for a field and laboratory study to complete a series of monographs on the mollusks of the Eocene formations of the southeastern states.

Dr. Charles Deiss, professor of geology, Montana State University, $400 to continue studies leading to the revision of the Cambrian rock formations in the Canadian Rockies and the northwestern states.

Dr. Charles F. Bassett, assistant professor of geology, the University of Kansas City, $300 to collect fossils and to study a section of Paleozoic rocks near Dotsero, Colo.

Dr. Richard Foster Flint, professor of geology, Yale University, $365 for an examination and interpretation of the glacial deposits in Columbia River Canyon, exposed during the construction of Coulée Dam.

Dr. J. Hoover Mackin, assistant professor of geology, the University of Washington, $260 for a revision of the glacial geology of the Puget-Juan de Fuca region of Washington.

Arthur Keith, U. S. Geological Survey, Washington, D. C., $665 to continue and complete his studies of Appalachian structure and stratigraphy in the Province of Quebec and adjacent areas.

A SPECIAL RESEARCH CONFERENCE ON CHEMISTRY

THE Section on Chemistry (C) of the American Association for the Advancement of Science has organized a new type of conference under the direction of Dr. Harold C. Urey and Dr. Neil E. Gordon, who are respectively the chairman and the secretary of the section. This conference will be held at Gibson Island, Maryland, from August 15 to 26, inclusive.

The program is as follows:

A. *Relation of Structure to Physiological Action,* Harold C. Urey, *chairman.* August 15–19.

August 15. Walter H. Hartung, "Relationship between Structure and Physiological Activity of Epinephrine and Ephedrine-like Compounds."

August 16. John H. Speer, "Purine Derivatives as Coronary Dilators—Relation of Structure to Activity."

August 17. Arthur C. Cope, "The Relation of Structure to Physiological Activity in Several New Series of Barbituric Acid Derivatives."

August 18. Edward A. Doisy and D. W. MacCorquodale, "The Relation of Molecular Structure to Androgenic, Estrogenic and Progestational Activity."

August 19. George W. Raiziss, "The Relation of Structure to Therapeutic Activity and Toxic Effect of Chemical Compounds with Particular Reference to Sulfanilamide and Related Compounds."

B. *Cellular Metabolism and Tissue Respiration*, C. G. King, *chairman*. August 22–26.

August 22. Kurt G. Stern, "Heavy Metal Catalysts in Tissue Metabolism."
C. V. Smythe, "The Identification of the Factor in Tissue Extracts that Stimulates the Fermentation of Yeast Cells."

August 23. K. A. C. Elliott, "Substances Which Behave Both as Intermediary Metabolites and as Respiratory Catalysts."
C. G. King, "Tissue Reactions of Vitamin C."

August 24. R. W. Gerard, "Neural Metabolism in Relation to Function."
Frederick Bernheim, "The Action of Certain Drugs on Cell Respiratory Catalysts."

August 25. M. E. Krahl, "Mechanism of Action of Certain Metabolic Stimulants."

August 26. Frances F. Beck and John C. Krantz, Jr., "Hydrogen-ion Concentration Studies on Tumor and Muscle."
C. Jelleff Carr and John C. Krantz, Jr., "Tissue Studies of Picrotoxin-Barbiturate Antagonism."

The sessions will begin at 10 o'clock, with one or two formal papers outlining the fields of research and directing attention to the unsolved problems. Since not more than two papers will be given on any one day, it will not be necessary to limit the discussions of the papers in any way. The program will also permit time for certain recreational features which the island affords.

Since accommodations on the island are limited, it is advisable to make reservations in advance. For reservations or for further information about the conference, write the secretary of the Section on Chemistry (C) and of the Conference, Neil E. Gordon, Central College, Fayette, Missouri.

F. R. Moulton,
Permanent Secretary

SCIENTIFIC NOTES AND NEWS

The doctorate of science was conferred at its two hundred and eighty-seventh commencement by Harvard University on Dr. Frank R. Lillie, director of the division of biological sciences at the University of Chicago; on Dr. Wendell M. Stanley, associate member of the Rockefeller Institute for Medical Research, Princeton, N. J., and on Dr. Irving Langmuir, associate director of the Laboratories of the General Electric Company at Schenectady, N. Y.

The doctorate of laws was conferred at the commencement of Dartmouth College on Dr. James Bryant Conant, president of Harvard University.

Dr. Robert R. Williams, chemical director of the Bell Telephone Laboratories, New York City, was the recipient of the honorary degree of doctor of science, conferred upon him by the Ohio Wesleyan University, Delaware, on June 13 "in recognition of his work in the chemistry of Vitamin B_1."

The degree of doctor of laws was conferred at the ninety-seventh annual commencement exercises of the University of Missouri on Dr. Frederick Lee Hisaw, professor of zoology at Harvard University, a graduate of the University of Missouri. Dr. Hisaw gave the commencement address. His subject was "The Productive Scholar."

Degrees conferred by the University of Rochester included the degree of doctor of science on Dr. Alice Hamilton, assistant professor emeritus of industrial medicine at Harvard University, and on Dr. Thomas Milton Rivers, director of the Hospital of the Rockefeller Institute for Medical Research, New York City.

The University of Nebraska at its sixty-seventh annual commencement conferred the doctorate of science on Dr. John Torrence Tate, professor of physics and dean of the College of Science, Literature and Arts of the University of Minnesota, and the doctorate of laws on Dr. Harry Levi Hollingworth, professor of psychology in Barnard College, Columbia University, and on Dr. Leta Stetter Hollingworth, professor of educational psychology, Teachers College, Columbia University. Both Mr. and Mrs. Hollingworth graduated in 1906 from the University of Nebraska.

At the one hundredth annual commencement on June 6 of Wabash College, the doctorate of laws was conferred on Dr. George H. A. Clowes, director of research of Eli Lilly and Company, Indianapolis, and

on Eli Lilly, president of the company. The cornerstone of the Goodrich Hall of Physical Sciences was laid on the same day. The subject of the foundation address on this occasion was "Science in Education." It was given by Dr. Alphonse M. Schwitalla, dean of the Saint Louis University School of Medicine.

DR. A. O. LEUSCHNER, professor of astronomy and director of the Students' Observatory, emeritus, of the University of California, has been elected a foreign associate of the Royal Astronomical Society of England, in recognition of his "eminent services to the science of astronomy." As already announced, he will this summer give the Halley lecture at the University of Oxford.

A DINNER in honor of Dr. G. Canby Robinson, now connected with the Johns Hopkins Hospital, who served as dean of the School of Medicine of Vanderbilt University from 1920 to 1928, was given by his former colleagues on June 7. On this occasion a portrait of Dr. Robinson, painted by Thomas Corner, of Baltimore, was presented to the university on behalf of a number of friends, by Dr. E. W. Goodpasture, professor of pathology. Chancellor O. C. Carmichael accepted the portrait for the university. It will be hung in the School of Medicine. A book of clippings and photographs showing the progress of the School of Medicine from its conception until the present, and containing the signatures of all guests at the dinner, was presented to Dr. Robinson. Chancellor Emeritus James H. Kirkland spoke on the history of the School of Medicine; Dr. Waller S. Leathers, dean of the school, gave an address on Dr. Robinson's service to the school and his personal qualities; Dr. W. H. Witt and Dr. Hugh Morgan spoke as representatives of the community and the medical faculty; Dr. Glenn Cullen, director of the Pediatric Research Institute of Cincinnati, formerly professor of biochemistry at Vanderbilt University, represented the medical profession.

DR. RUSSELL H. ANDERSON, curator of agriculture at the Museum of Science and Industry, Chicago, has been elected president of the Agricultural History Society, the headquarters of which are in Washington, D. C. He succeeds Dr. M. L. Wilson, under-secretary of agriculture of the United States. Other officers elected were: *Vice-president,* Dr. Carl R. Woodward, of Rutgers University; *Secretary-treasurer,* Dr. O. C. Stine, of the U. S. Department of Agriculture; *Members of the Executive Committee,* Professor Harry J. Carman, of Columbia University, and Dr. Arthur G. Peterson, of the U. S. Bureau of Agricultural Economics.

OFFICERS elected at the Washington meeting of the American Institute of Electrical Engineers, for the year beginning August 1, are: *President,* Dr. John C. Parker, vice-president of the Consolidated Edison Company of New York; *Vice-presidents,* Chester L. Dawes, Cambridge, Mass.; F. Malcolm Farmer, New York, N. Y.; A. H. Lovell, Ann Arbor, Mich.; F. C. Bolton, College Station, Texas; Lester R. Gamble, Spokane, Wash.; *Directors,* Leland R. Mapes, Chicago, Ill.; Harold S. Osborne, New York, N. Y.; D. C. Prince, Philadelphia, Pa.; *National Treasurer,* W. I. Slichter, New York, N. Y. (reelected).

NOMINATIONS for officers of the American Society of Mechanical Engineers for 1939 were announced at the semi-annual meeting at St. Louis. Election will be held by letter ballot of the entire membership, closing on September 27. The nominations include for president, Alexander G. Christie, professor of mechanical engineering at the Johns Hopkins University; and for vice-presidents, Henry H. Snelling, senior member, Snelling and Hendricks, Washington, D. C.; W. Lyle Dudley, vice-president, in charge of design and sales of the Western Blower Company, Seattle, Wash.; James W. Parker, vice-president and chief engineer of the Detroit Edison Company; and Alfred Iddles, application engineer of the Babcock and Wilcox Company, New York, N. Y.

DR. F. B. MUMFORD, dean of the College of Agriculture of the University of Missouri, will retire as dean on September 1, when he will become dean emeritus. He will conduct research next year, under a limited appointment, on the organization and administration of agricultural education in the United States through the research department of the Agricultural Experiment Station. He has served forty-four years on the college faculty.

PURSUANT of the policy in force at the Iowa State College of relieving staff members of administrative work at the age of sixty-five years, Professor A. H. Fuller, head of the department of civil engineering, and Professor Martin Mortensen, head of the department of dairy industry, will now devote their time exclusively to teaching and research. Professor L. O. Stewart has been appointed head of the department of civil engineering, and Professor C. A. Iverson has been appointed head of the department of dairy industry.

E. A. HERSAM, for forty-five years professor of metallurgy at the University of California, retired as professor emeritus on June 30, having reached the age of seventy years. He will be succeeded by Dr. Lionel H. Duschak. Dr. Duschak was for some time superintendent of the Berkeley Experiment Station of the U. S. Bureau of Mines, and since 1921 has been engaged in consulting work as chemical and metallurgical engineer, with headquarters in San Francisco.

DR. J. C. BLAIR, for thirty-eight years head of the

department of horticulture, has been appointed dean and director of the College of Agriculture of the University of Illinois. Dr. Blair succeeds the late Dean H. W. Mumford, who died on May 31 as a result of injuries received in an automobile accident. Dr. Eugene Davenport, who retired in 1922, was the first dean and director. Professor Blair, in addition to being dean of the college, will be director of the experiment station and of the extension service in agriculture and home economics. It is understood that he also will continue as head of the department of horticulture.

DR. KENNETH F. MAXCY has resigned as professor and head of the department of bacteriology at the Johns Hopkins University to become professor and head of the department of epidemiology in the School of Hygiene and Public Health.

DR. JERZY NEYMAN, of the University College, London, formerly chief of the Agricultural Institute of Warsaw, will become in the autumn a member of the department of mathematics at the University of California at Berkeley. At Los Angeles new members of the faculty include Dr. James Gilluly, of the U. S. Geological Survey, and Professor T. Y. Thomas, of the department of mathematics of Princeton University.

DR. JANET HOWELL CLARK, formerly associate professor and now lecturer at the Johns Hopkins University and since 1935 head of the Bryn Mawr School in Baltimore, has been appointed professor in the division of biological sciences and dean of the College for Women at the University of Rochester.

FRANCIS MCBRYDE TAYLOR, assistant in chemical engineering at the Ohio State University and formerly chemical engineer for the Tennessee Eastman Corporation, has been appointed assistant professor of chemical engineering at Tulane University.

DR. ALEXIS CARREL sailed for Europe on June 22 to continue work in his laboratory on St. Gildas Island, off the coast of Brittany. Dr. Carrel will retire from the Rockefeller Institute for Medical Research in July, 1939.

THE Bernice P. Bishop Museum of Honolulu, in continuation of its program on exploration in Oceania, has sent Dr. C. Montague Cooke, Jr., staff malacologist, his assistant Y. Kondo, and Elwood C. Zimmerman, staff entomologist, to Fiji for three months of intensive field work. They will collect insects and land shells, placing special emphasis on the rediscovering of "lost" species and the gathering of data pertinent to Pacific zoogeography. Some of the more important islands of the Lau group, Ovalau and Viti Levu will be visited.

SHARAT K. ROY, curator of geology at the Field Museum of Natural History, Chicago, has left Chicago on June 18 by automobile to take part in a geological expedition sponsored by Sewell Avery, of Chicago. It is planned to collect rock specimens illustrating phases of physical, dynamic and structural geology in both western and eastern regions of the United States. This is the first of four expeditions for the museum this year under the sponsorship of Mr. Avery, who is a trustee of the museum. Later in the season a botanical expedition will collect intertidal plants in the Bay of Fundy region, Nova Scotia; a zoological expedition will be dispatched to British Guiana, and a second botanical expedition will go to Guatemala.

THE Institute of Medicine of Chicago announces that competition for the 1938 Joseph A. Capps Prize, founded by the late Dr. Edwin R. LeCount, is open to graduates of the medical schools of Chicago who completed their internship or one year of laboratory work in 1936 or thereafter. The prize of $400 is awarded for the most meritorious investigation in medicine or in the specialities of medicine; investigation may also be in the fundamental sciences provided the work has a definite bearing on some medical problem. Manuscripts should be submitted to the Institute of Medicine of Chicago, 86 East Randolph Street, Chicago, not later than December 31.

DISCUSSION

MAXIMUM CONVENIENCE IN CITATIONS

THROUGH the years of my experience with scientific periodical literature, first as a student and then as a librarian, the conviction has been growing in me that the one thing which would do most to facilitate the use of libraries by research workers is a reform in the matter of citations. No one who has not sat behind a librarian's desk could guess the total time that is lost in fumbling over obscure references which might just as easily be right. Yet the same persons who are bothered by mis-citations feel obliged to perpetuate the identical handicaps because no other precedent is set them. A note on the subject at this time is prompted by the recent appearance of a new edition of an admirable handbook on the preparation of scientific papers by Professors Trelease and Yule[1] to which

[1] S. F. Trelease and E. S. Yule, "Preparation of Scientific and Technical Papers." 3d ed. Williams and Wilkins, 1936.

exception is to be taken on this one point only, the instructions and examples covering the question of abbreviations for periodical titles (pp. 85–95).

Approximately 75,000 titles are contained in the original edition of the *Union list of serials,* thousands more will be added in the revised edition now in progress, and in even a fair-sized library catalogue there are several thousand. To find one's way about readily in this large territory of literature obviously requires a real technique, and since the cataloguing of these serials throughout American libraries has been completely standardized by adherence to Library of Congress rules and this *Union list,* the test of a correct citation is clearly that it conform to their procedure, so that the user is led by the citation directly to the right place in the finding list. The guiding principle in formulating a reference, in other words, is that it should begin with the word which is the key word in the catalogue. The following corollaries indicate the details of the way in which the principle works itself out.

(1) In the case of society, academy or university publications, the institution comes first and the title second. A conversational order is now generally followed, which it should be a simple matter to learn to invert when one approaches a catalogue. But actually it may be explained to a man that just as one looks for books, not under "Introduction to . . ." or Vorlesungen über . . . ," but under the author, so one must expect in any catalogue to find the order:

Cambridge philosophical society.	*Proceedings.*
National academy of sciences.	*Proceedings.*
U. S. Bureau of Standards.	*Bulletin.*
" " " "	*Journal of Research.*
" " " "	*Technical papers.*

yet none-the-less the same man will next time make a similar attempt to find the *Comptes Rendus* or *Verhandlungen* of his reference. It may even be that he is not given the corporate author at all. To one long since instructed, *Phil. Trans.* alone may seem sufficient, but beginners with the desire to help themselves should not be subject to the embarrassment of admitting, "I can't find any *Philosophical transactions.* What are they?" An extreme case of this sort was recently encountered in a biological paper in the *Journal of Applied Physics,* simply *"Ber."* A look at the *Union list* suggested that this might be the biologists' jargon for his *Berichte über die gesamte physiologie,* properly a title entry. But checking and further search in *Biological Abstracts* revealed the fact that the reference is in fact to a *Berichte* which could be found in any catalogue only under the entry *Deutsche chemische gesellschaft.* Another similar mistake is the frequent use of *Ber. Ber.* for *Preussiche akademie d. wissens. Sitz. ber.*

This practice of using the catalogue order in abbreviations is now followed almost consistently by *Science Abstracts,* though apparently not by any other of the abstracting services. All the H. W. Wilson indexes of course use it, as do other major library tools. It may sound at first artificial to other than librarians, but its adoption would prevent much waste of effort and we do have precedent for our encouragement.

(2) An editor's name should be avoided unless it is officially in the title. *E.g.,* not *Poggendorff's Annalen,* but *Ann. d. physik, ser. 2* or *Ann. d. physik* (2). *Pflüger's Archiv,* on the other hand, is suspect, but turns out to be correct.

(3) The vernacular should be adhered to, not a translation. *E.g.,* not *Contributions of the Observatory of Lund,* but *Lund. Observ. Meddel. Acad.* is sure to cause trouble when it should be *Akad.* or *Accad.*

(4) Unless one is understood to be using some particular list with a key provided, one should not abbreviate too far, particularly the first word. *E.g.,* most persons would have to look in *Science Abstracts* for the meaning of *A.T.M.,* and *Archiv f. tech. mess.* is not much longer. *Inst. el. eng., Jour.* is safer than *J.I.E.E.,* particularly if it stands a chance of being printed *J.I.E.F. Soc. de biol.* is better than *Soc. biol.* because *Société biologique* and *Société de biologie* are surprisingly far apart in many catalogues.

(5) When an institution is organized in parts, *Math.-phys. kl., Sect. I,* or whatever the case requires, should be added. This may seem obvious to both writer and reader, but when the reference is turned over to some one who does not know of the division, or does not know the context, as when it is the basis of an interlibrary loan, or a telephone call from one part of a library system to another, the omission may well lead to serious difficulty.

(6) For the same reason, the series should always be given in case the set is numbered in series. There are circumstances in which the date does not take its place.

The older literature and the foreign will still provide sufficient occasions when a man must wait to ask a specialist in library detective work "What does this reference mean?" if our own technique of citation were improved beginning now. It requires only a little consideration from the point of view here presented, and in cases of doubt there will almost always be a librarian available to help edit a bibliography. This will be work of a constructive rather than a corrective sort in which, like other people, librarians take particular pleasure. On essential points of this proposal all library editing would undoubtedly be consistent.

Margaret C. Shields
Fine Hall Library, Princeton, N. J.

UNIOVULAR TWINS IN MICE

CASTLE, Gates, Reed and Snell[1] reported a probable case of identical twins in mice. Recently Stevens[2] has suggested that though the probability of the pair being both crossovers and also identical in two color factors and sex by chance combination is indeed small, the probability of a single crossover egg giving rise to monozygotic twins is also comparably small. It would be desirable to determine which of the two probabilities is more likely. Unfortunately, this can not be done because the necessary data are no longer available.

It may be well, however, to point out some consequences of Stevens's work which may be of interest to investigators watching for possible cases of identical twins in the laboratory mammals.

In a backcross population involving six pairs of non-linked genes (plus the sex difference) one expects 128 equiprobable genotypes. Stevens devised a scoring system whereby two genetically identical litter mates score *one,* three genetically identical litter mates score *two,* and so on. With 128 equiprobable genotypes the expected total score is 22.305 for the 180 litters of 1,030 mice which Stevens studied. Stevens's observed score was only seventeen; the 1,030 mice probably contained few, if any, pairs of uniovular twins.

Table I gives the total expected scores for various numbers of equiprobable genotypes in backcross populations. The scores are not corrected, but the corrections will never amount to a large percentage of the total score. The writer has used Stevens's formulae and data to calculate the components of the table. The calculated total score in each case is for his population of 1,030 mice arranged in the same litter sizes.

TABLE I

THE TOTAL EXPECTED SCORE (UNCORRECTED) FOR STEVENS'S POPULATION OF 1,030 MICE FOR VARIOUS EQUIPROBABLE GENOTYPES

No. of factor pairs	No. of equiprobable genotypes	Total expected score
4	16	158.511
5	32	83.519
6	64	42.989
7	128	21.729
8	256	10.925
9	512	5.487
10	1,024	2.278
11	2,048	1.379

It is clear that each additional factor pair doubles the number of equiprobable genotypes and halves (approximately) the total expected score. The standard deviation may be calculated for each total score, thus setting the upper limit of chance identities, an excess of which, in the observed score, could be considered evidence of uniovular twinning.

Investigators observing segregation of ten or more pairs of factors in large backcross populations can get a rough estimate from the table of the expected score per 1,000 mice and decide whether their observed score is sufficiently in excess of the expected to be considered evidence of uniovular twinning.

Where the frequency of uniovular twins is low, as in mice (less than seven pairs per thousand, according to Stevens), it will be necessary to study backcross populations segregating for ten or more pairs of factors so that the number of expected chance genetic identities will be small compared with the number of pairs of uniovular twins (if any). As backcrosses involving ten or more pairs of factors present grave practical difficulties, detection of possible uniovular twins in mice is likely to be accomplished by observation of embryos or by some new technique rather than by a study of backcross populations.

SHELDON C. REED

DEPARTMENT OF GENETICS,
MCGILL UNIVERSITY

[1] SCIENCE, 84 (2191): 580, December 25, 1936.
[2] *Annals of Eugenics,* 8: 70–73, 1937.

FRESH-WATER MEDUSAE IN ARKANSAS

ALTHOUGH reported from adjoining states (Oklahoma,[1] Missouri[2] and Texas[3]), there appear to be no records of fresh-water medusae in Arkansas. The following two records, although unaccompanied by specimens, indicate their presence. The first report is from a student (C.A.) who recognized *Obelia* medusae used in the elementary zoology laboratory as apparently the same as what he had seen in Blue Lake, near Prescott, Arkansas, late in the summer of 1927. There he had found thousands and kept a few alive for several days. His description of their form and movements left no doubt of his observation. The second report is from Professor W. C. Munn, of the State A. and M. College at Magnolia, Ark., who found thousands of medusae in a pond near Stamps, Arkansas, late in the summer of 1937. The pond, by an abandoned mill, has been used for storing pine logs for some 25 or 30 years. Specimens collected and preserved were unfortunately lost in transportation.

The sites from which the medusae are reported are within a hundred miles of Broken Bow, Oklahoma, where Ortenburger and Phillips (1931) found medusae, and approximately two hundred miles from Dallas, Texas, where Cheatum (1934) discovered the same form. The general similarity of this area suggests that the fresh-water medusae will also be found in the adjacent portion of Louisiana, from which they seem not to have been reported, and quite possibly, from the coastal plain area of Arkansas generally.

DAVID CAUSEY

UNIVERSITY OF ARKANSAS

[1] Ortenburger and Phillips, SCIENCE, 74: 222, 1931.
[2] Bennitt, *Amer. Nat.,* 66: 287–288, 1932; Atwood and Steyermark, *ibid.,* 71: 280, 1937.
[3] Cheatum, SCIENCE, 80: 528, 1934.

SOCIETIES AND MEETINGS

THE KENTUCKY ACADEMY OF SCIENCE

FOR its twenty-fifth annual meeting, which was held on May 13 and 14, the Kentucky Academy of Science enjoyed the hospitality of the Morehead State Teachers College, Morehead, Kentucky. Dr. Fernandus Payne, of Indiana University, was the guest speaker.

The following divisions of the academy participated: Biology; Chemistry; Geology and Geography; Kentucky Section of the Mathematical Association of America; Louisville Astronomical Society; Philosophy and Psychology; Kentucky Section of American Association of Physics Teachers; Social Sciences. Fifty-three papers were read, two papers were read by title, and four were given by demonstration. The Division of Social Sciences held a panel discussion on "Federal Regulation of Hours and Wages," in which six scheduled speakers participated.

A sight-seeing trip into the Cumberland National Forest was conducted and enjoyed by all who went. A scheduled trip to the Carter Caves was canceled because of stormy weather on Saturday, May 14.

Among the resolutions adopted were two of general interest. These were adopted by unanimous vote and are as follows:

1. (*a*) That the Kentucky Academy of Science places itself on record as endorsing the action of the California Society for the Promotion of Medical Research in its resistance to the proposed California so-called "Humane Pound Law" which would greatly curtail scientific experimentation in which live animals are used.

(*b*) A reiteration of a resolution of former years condemning all types of anti-vivisection laws designed to destroy modern physiological and medical research.

2. That the Kentucky Academy of Science stands with other good and patriotic citizens in opposition to the enactment of Senate Bill 3925 to authorize the construction of a dam at Yellowstone Lake and a tunnel for the diversion of water from that lake to a tributary of the Snake River. It voices its opposition to all similar acts proposing the conversion of natural areas in National Parks.

The general officers of the Kentucky Academy of Science elected for the year 1938–1939 are:

President, Dr. W. R. Allen, University of Kentucky.

Vice-president, Dr. James L. Leggett, Transylvania College.

Secretary, Dr. Alfred Brauer, University of Kentucky (reelected).

Treasurer, Professor Wm. J. Moore, Eastern Kentucky State Teachers College, Richmond.

Representative on Council of A. A. A. S., Dr. Austin R. Middleton, University of Louisville (reelected).

Councilor to Kentucky Junior Academy of Science, Dr. Anna A. Schnieb, Eastern Kentucky State Teachers College (reelected).

ALFRED BRAUER,
Secretary
UNIVERSITY OF KENTUCKY

THE UTAH ACADEMY OF SCIENCES, ARTS AND LETTERS

THE thirty-first annual meeting of the Utah Academy of Sciences, Arts and Letters was held at the Utah State Agricultural College in Logan, on May 13 and 14. The banquet meeting was held Friday evening, May 13, from 6:00 to 8:00 P.M. at the Bluebird Café. The program was furnished by the Utah State Agricultural College commemorating the fiftieth anniversary of the founding of the institution. Director William Petersen was the toastmaster. Addresses were made by Dr. John A. Widtsoe, fifth president of the college, and Dr. E. G. Peterson, sixth and incumbent president. One hundred and ten were present.

At 8:00 P.M. the annual evening meeting of the academy was held in Chapel Hall at the college. The Bel Canto Ladies Chorus, under the direction of Professor Walter Welti, of the college, furnished a number of beautiful selections. The annual presidential address was then given by Dean Milton Bennion, president of the academy, his subject being "The Contribution of Philosophy to Civilization." Professor A. N. Sorensen, of the English Department, Utah State Agricultural College, then presented a paper titled, "Literature in the Modern World."

The members of the academy executive council were the guests of President E. G. Peterson at a breakfast in the Commons Building from 7:00 to 9:00 A.M. Saturday morning, May 14.

At 9:00 A.M. a general session was held in the Auditorium of the Engineering Building, at which President Milton Bennion presided. The following papers were read: "Social Security Programs of the Mormon Church under Joseph Smith and Brigham Young," by President F. Y. Fox, L. D. S. Business College, Salt Lake City, and "Utah Literature, from the Utah State Guide Book," by Mr. Maurice L. Howe, director of the Utah Federal Writer's Project.

The following were then announced as elected as officers of the academy for the following year: *President*, M. Wilford Poulson, of the Brigham Young University; *First Vice-President*, Ralf R. Woolley, Salt Lake City; *Second Vice-President*, A. L. Beeley, University of Utah; *Council members*, Reed Bailey, U. S. Forest Service, Joseph E. Greaves, Utah State Agricultural College, and Thomas C. Adams, University of Utah. Thirty-three new members were elected.

The various section meetings began at 10:00 A.M. In the Physical Science Section fourteen papers were given. The geologists of the Physical Science Section inaugurated a field day this year. The excursion was under the direction of Dr. J. S. Williams, of the Utah

State Agricultural College, who met the geologists and students, sixty in all, at 8:00 A.M., Friday, May 13, at Brigham City and conducted them through Cache Valley. Many interesting features were visited and studied. Twenty-four papers were presented in the Biological Section, five in the Social Science Section and six in the Arts and Letters Section.

A vote of thanks and appreciation was extended to the local committee—Drs. W. W. Henderson, *Chairman*, Bert L. Richards and O. W. Israelson—and the officials of the college for the splendid manner in which they handled the academy meetings.

It was decided to hold the autumn meeting of the academy at Brigham Young University.

VASCO M. TANNER,
Permanent Secretary-Treasurer

SPECIAL ARTICLES

ON THE PROPERTIES OF RECTILINEAR FIGURES OF n DIMENSIONS

SOME years ago the writer derived some curious relations between functions of the expression 2^n which appear to be of sufficient interest to publish.

TABLE I

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
n =	0	1	2	3	4	5	
2^n	1	2	4	8	16	32	Points
$\frac{n}{1}.2^{n-1}$		1	4	12	32	80	Lines
$\frac{n(n-1)}{2!}.2^{n-2}$			1	6	24	80	Areas
$\frac{n(n-1)(n-2)}{3!}.2^{n-3}$				1	8	40	Volumes
$\frac{n(n-1)(n-2)(n-3)}{4!}.2^{n-4}$					1	10	*
$\frac{n(n-1)(n-2)(n-3)(n-4)}{5!}.2^{n-5}$						1	*
Figures of :—	0 dimensions (Points)	1 dimension (Lines)	2 dimensions (Squares)	3 " (Cubes)	4 " (Tesseracts)	5 "	

From the expression 2^n, if we derive the expressions:

$$\frac{n}{1}.2^{n-1};\ \frac{n(n-1)}{2!}.2^{n-2};\ \frac{n(n-1)(n-2)}{3!}.2^{n-3};\ \frac{n(n-1)(n-2)(n-3)}{4!}.2^{n-4};$$

etc., with, as the m^{th} term:

$$\frac{n(n-1)(n-2)(n-3)\ .\ .\ .\ (n-m+2)}{(m-1)!}.2^{n-m+1}$$

and in them substitute for n the values 0, 1, 2, 3, 4, . . ., Table I can be prepared.

In column (2) the properties of a point are described, and in columns (3), (4) and (5) the properties of lines, squares and cubes respectively. In column (6) the tesseract, which possesses 8 cubes, 24 squares, 32 lines and 16 points, is indicated. It seems reasonable to conclude, therefore, that column (7) would indicate the properties of the corresponding fifth-dimensional figure, whilst the extension of these expressions would remain true for rectilinear figures of n-dimensions.

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PHOSPHORYLATION OF GLYCOGEN IN VITRO

PHOSPHORYLATED carbohydrates are of particular interest in view of the role of phosphorylated intermediates in the breakdown of glycogen by muscle enzymes. The synthesis of phosphorylated glycogen was therefore undertaken. The preparation of a new compound, namely, the calcium salt of the phosphoric acid ester of glycogen, is described.

The method for phosphorylating glycogen adopted was similar to that employed by Kerb[1] for phosphrylation of starch. Thirty grams of glycogen (free of phosphorus) were dissolved in 750 cc of hot water and, after cooling, 120 gm of calcium carbonate were added. The mixture was then cooled to about 3° and 25 gm of phosphorus oxychloride in 75 cc of chloroform

[1] J. Kerb, *Biochem. Z.*, 100: 3, 1919.

added dropwise while the mixture was stirred; stirring was continued for 4 hours. The mixture was next allowed to stand for 6 hours, then filtered through a Büchner funnel and the precipitate washed with 700 cc of water. The filtrate was concentrated at 40° C. *in vacuo* to a volume of approximately 200 cc and its glycogen precipitated by the addition of an equal volume of 95 per cent. alcohol. The precipitate was permitted to settle, then filtered and washed with alcohol. Further purification was effected by twice redissolving in water and reprecipitating from alcohol. Finally it was dried *in vacuo* at 40° to constant weight. This phosphorylated glycogen contained 0.43 per cent. phosphorus and 0.57 per cent. calcium.

The phosphorylation was repeated 7 times by the above method, with a consequent increase in its phosphorus content each time. After the seventh operation, the phosphorylated glycogen contained 1.73 per cent. phosphorus and 2.66 per cent. calcium. Its specific rotation $(\alpha)_D$, after being dried *in vacuo* at 40° to constant weight, was +174°.

The phosphorylated glycogen was soluble in water and the presence of ionic calcium was demonstrated by its precipitation upon the addition of ammonium oxalate. No test for phosphate was obtained with ammonium molybdate, even after acidifying and boiling with dilute nitric acid for a few minutes. Phosphoric acid was split off, however, by treating the phosphorylated glycogen with a few cc of hydrogen peroxide and several drops of nitric acid containing a trace of ferric nitrate, after the manner of Neuberg and Mandel.[2]

The phosphorylated derivatives obtained by enzymatic hydrolysis of the phosphorylated glycogen will be described elsewhere.

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A PRELIMINARY REPORT ON THE SPECIFICITY OF KERATINS[1]

ALTHOUGH species specificity is a general attribute of proteins, serological species differences of keratins have been generally accepted as either poorly defined or not demonstrable.

The experiments of Krusius,[2] in which he employed antiformin for the preparation of keratin, led to hydrolysis and alterations in the protein-molecule which may account for the lack of specificity of keratins from different species. Krusius himself realized this possibility.

Recently, Goddard and Michaelis[3] observed that keratin owes its peculiar resistance against dissolving agents to the di-sulfide bonds in their original positions, which are mainly responsible for the pattern of the structure of keratin and also its physical properties. These observers were able to split these di-sulfide groups by reducing agents in such a manner as to leave intact the chemical composition and avoiding hydrolytic splitting. The reduced protein obtained was called "kerateine" and it behaved more like an ordinary protein than native keratin, both with respect to solubility and behavior toward proteolytic enzymes.

The immunological investigations to be described here were primarily directed toward the study of the antigenic power and specificity of oxidized and reduced keratins prepared by the method of Goddard and Michaelis.

Keratins were prepared from human hair, wool and chicken feathers. Elementary chemical analysis revealed that the compounds are closely related. The total nitrogen, sulfur, cystine and isoelectric points are essentially identical in all the preparations employed.

In brief, the results of these studies disclosed that species specificity is an individual characteristic of the keratins employed and that the specificity observed is dependent on the redox state of the sulfhydryl groups in the protein molecule.

In cross-precipitation reactions overlapping was encountered, and especially in low dilutions of the antigens; but in the very dilute antigens, *i.e.*, (±1:25,000), the antiserums gave specific precipitates in the presence of their homologous antigens.

Of greater significance is the finding that species specificity was obtained only when the reduced keratin (kerateine) was allowed to react with the antiserum prepared by the injection of the homologous reduced keratin; while marked overlapping occurred when oxidized keratin (metakeratin) and the parent protein (75 per cent. oxidized) were employed as antigens.

The same phenomenon was observed when oxidized keratin was allowed to react with its homologous antiserum. This indicates that not only are the keratins species specific, but that immunological differences are detectable in a single keratin preparation depending on the state of oxidation or reduction of the protein employed.

It would seem, as data upon the basic amino acids content of proteins accumulate, that recognition must be given to the view that there exists a central basic nucleus characteristic for any one biological type of

[2] C. Neuberg and J. A. Mandel, *Biochem. Z.*, 71: 196, 1915.

[1] From the Institute of Pathology, Western Reserve University and the University Hospitals, Cleveland, Ohio. Aided by a grant-in-aid, Division Medical Sciences, National Research Council.

[2] Fr. F. Krusius, *Arch. f. Augenheilkunde*, Supplement, 67: 47, 1910.

[3] D. R. Goddard and L. Michaelis, *Jour. Biol. Chem.*, 106: 605, 1934.

protein around which the remaining amino acids are united. This view, first advanced by Kossel, was recently substantiated by Block.[4]

Taking into consideration the importance of the terminal amino acids in the experiments of Landsteiner and Van der Scheer,[5] in which peptides were introduced as "determinant groups" it appears plausible that the immunological characters of proteins are determined by the arrangements of amino acids on the surface of the molecule.

If these views are accepted all keratins must possess a peculiarity in chemical structure that characterizes them as keratins, but among these chemically similar substances there must exist a special variant in each species to account for the specificity exhibited by each type of keratin. This may be due to the nature and spatial arrangement of the terminal amino acids, especially cystine and cysteine.

The differences observed between the reactions of oxidized and reduced keratins may possibly depend on the fact that either the—S-S—or—SH groups operate as "determinants," or that the reduction of the—S-S—linkage may produce an inter- or intramolecular rearrangement. An extensive report of these experiments and also on keratin derivatives will appear elsewhere.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MECHANISM FOR THE AUTOMATIC IRRIGATION OF SAND CULTURES[1]

A VERY satisfactory mechanism for the automatic irrigation of sand in culture experiments can be constructed from stock equipment or from parts that can be readily obtained. The containers for the sand must have an outlet at the bottom through which the culture solution is introduced and withdrawn, and the table on which the containers are placed must be of sufficient height to permit the placing, underneath, of the control mechanism and the carboys which supply the culture solution. With this mechanism any number of sand containers may be simultaneously irrigated and any container or group of containers may be supplied with any desired culture solution. The diagram shows the arrangement of the apparatus.

A vessel (a), made from an inverted one-liter wide-mouthed bottle with the bottom removed, is placed above the table and is adjustable for height. It is connected by a tube (b) to one of the carboys supplying culture solution and by the flexible tube (c) to the top of vessel (d). In vessel (a) tube (b) is brought nearly to the top, and tube (c) is formed into a siphon of 5 mm bore. Vessel (d) is an asphalted metal pan of 7½ inches diameter and of slightly more than 1 liter capacity, to the bottom of which is soldered an iron bar (e) which extends out approximately 18 inches. Through an outlet in the bottom, this vessel is connected by the flexible tube (f) to the top of the same carboy to which vessel (a) is connected. In the tube (f) is inserted a one-way glass valve, which permits flow of solution from the vessel but prevents escape of air from the carboy. The bar (e) is supported by a bearing 7 inches from the vessel (d) and its outer end is attached to the handle of a three-way valve (g). One arm of the valve is connected to the top of the carboy. One arm is attached to a compressed air main (h) carrying 5 pounds of pressure and the remaining arm is unattached. The valve is so arranged that when the vessel (d) is in the "down" position the carboy air line is connected to the unattached arm, and when the vessel (d) is in the "up" position the compressed air main is connected to the carboy air line. A small trip checks the downward

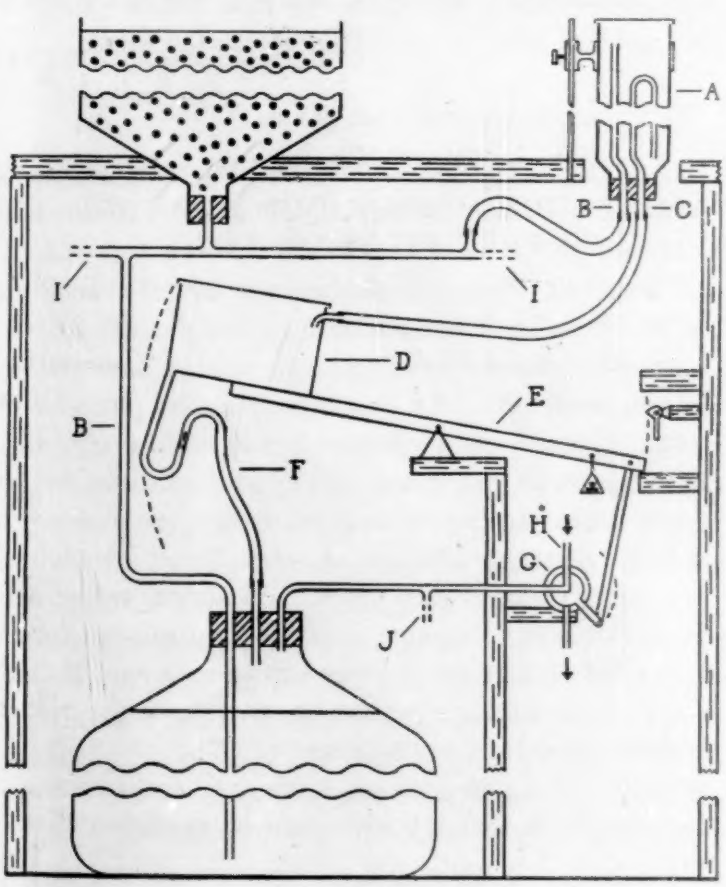

FIG. 1

[4] R. Block, *Jour. Biol. Chem.*, 103: 261, 1933; 105: 455, 1934; and *Proc. Soc. Exp. Biol. and Med.*, 32: 574, 1935.

[5] K. Landsteiner and J. van der Scheer, *Jour. Exp. Med.*, 55: 781, 1932; *ibid.*, 59: 769, 1934.

[1] Contribution No. 557, Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

movement of the end of the bar (e) and assures a quick and positive movement of the valve when the vessel (d) moves from the "down" to the "up" position. A suitable counter weight is suspended from the bar (e).

As indicated in the diagram, when the vessel (d) is in the "up" position air pressure from the compressed air main forces the culture solution up into the sand containers. As the solution rises in the sand it also rises in tube (b), the height of which is adjusted so that when the solution has almost reached the surface of the sand it overflows and fills vessel (a) until the siphon (c) is started. Vessel (a) then empties into vessel (d) where the weight of solution overcomes the balance weight, causing the rotation of the valve (g), shutting off the compressed air and releasing the air pressure in the carboy. The culture solution from the sand containers drains back into the carboy, while the one-way glass valve in the tube (f) allows the culture solution in the vessel (d) to drain back into the carboy. By constricting this tube the frequency of irrigation can be adjusted. When vessel (d) has emptied it returns to the "up" position and in so doing again turns on the compressed air at the valve (g).

Other sand containers irrigated from the same carboy are attached to the solution line (b) as indicated at (i). When additional culture solutions are to be used their carboys need only be connected to the air line, as shown at (j). Carboys need not be of the same size, but it is essential that the amount of solution in each carboy be so adjusted that when the compressed air is automatically shut off the level of the residual solution in all carboys is the same.

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A SIMPLIFIED TECHNIQUE FOR FORENSIC PRECIPITATION TESTS

Forensic precipitation tests for the identification of blood stains or other antigens can be carried out by merely placing small bits (1 sq. mm) of stained fabric, very thin wood shavings or a few particles of scrapings on a clean glass slide and adding one drop of the specific antiserum and control antisera to the test objects. In the presence of the specific antiserum, a macroscopic precipitate appears almost as soon as the object is thoroughly wetted. In normal rabbit sera or heterologous immune sera no precipitate forms. The addition of a small cover slip to each spot flattens the drop and makes it possible to observe the results with a hand lens or microscope. The cover slip is quickly sealed into position by drying of the serum at the margin so that the slides can be examined in any position.

The width of the zone of precipitation affords a rough indication of the relative potency of the extract and the antiserum. A strong antiserum in the presence of weak extract produces precipitate only around the object, while a potent source of extract causes a much wider zone of precipitate.

The method has several advantages other than the small amount of material required and the simplicity of the preparations. The preparation of extracts, and concern for their strength and clarity, is unnecessary. The extraction occurs by diffusion and the extracts are clear and undiluted. The outward diffusion of the antigen creates the different proportions of extract and antiserum which favor maximal precipitation. It has been shown that extracts or antisera which are too weak to give positive tests by the usual methods give positive results under these conditions. Since no extracting fluids are required, such controls can be omitted.

Photographic records of the results can be prepared more readily than in the case of tests prepared in tubes. Serological tests can be made under field conditions where only a lens, slides, cover slips and a few drops of antiserum can be carried with ease.

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